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Claims

[c1] A liquid-liquid extraction vessel, comprising:

a cylindrical shell having an inside diameter of at least 1.5 m;
an array of sieve trays vertically spaced in the shell;
a perforated deck in each tray;
a single riser or a pair of parallel risers in each tray, the risers having top and bottom sections wherein the bottom section has a cross-sectional flow area larger than a cross-sectional flow area of the top section;
an exterior manway formed in a wall of the vessel adjacent to at least one of the trays; and
a manway hatch formed in the perforated deck of each tray for personnel access to each of the trays.

[c2] The vessel of claim 1 wherein the manway hatches in each tray overlap in plan a manway hatch in an adjacent tray.

[c3] The vessel of claim 2 wherein the risers comprise alternating peripheral single-pass risers.

[c4] The vessel of claim 2 wherein the risers comprise alter-

nating midsection-peripheral two-pass risers

[c5] The vessel of claim 2 wherein the risers comprise alternating midsection-peripheral three-pass risers.

[c6] The vessel of claim 1 further comprising blanking strips removably secured to the perforated decks.

[c7] The vessel of claim 1 further comprising blanking strips adjustably secured to the perforated decks.

[c8] The vessel of claim 1 wherein the perforated decks comprise an assembly of a plurality of panels.

[c9] The vessel of claim 1 wherein the risers include a perforated restriction plate between the top and bottom sections.

[c10] A liquid-liquid extraction method for contacting a relatively heavy liquid phase with a relatively light liquid phase, comprising:

introducing a feed stream of the heavy phase for downward flow at a volumetric flow rate at an upper inlet of a liquid-liquid extraction vessel comprising a plurality of successive, vertically-arrayed trays including at least one perforated deck per tray and at least one riser per tray, wherein the risers include respective top and bottom sections, wherein the bot-

tom riser sections have larger transverse cross-sectional areas than respective top riser sections;

introducing a feed stream of the light phase into a lower inlet of the extraction vessel for upward flow as a continuous phase at a volumetric flow rate greater than the heavy phase flow rate;

passing the heavy phase through perforations in the decks of successive trays to disperse droplets of the heavy phase into respective cross-flow zones below the decks;

collecting the heavy phase on respective upper surfaces of the successive decks;

passing the light phase through respective cross-flow zones into adjacent disengagement zones and through the respective risers to discharge into succeeding cross-flow zones.

[c11] The method of claim 10, further comprising contacting the heavy and light phases above an uppermost one of the trays by:

distributing the heavy-phase feed stream adjacent the upper inlet across an upper distribution zone;

passing the light phase upwardly from the at least one riser of the uppermost tray for countercurrently contacting the heavy phase in the upper distribution zone;

passing the light phase upwardly from the upper distribution zone into an ultimate disengaging zone for separating heavy-phase droplets into the upper distribution zone, and for withdrawing from the disengaging zone the light phase essentially free of entrained heavy phase;

discharging the light phase as an effluent from an upper outlet of the extraction vessel in communication with the disengaging zone.

[c12] The method of claim 10, further comprising contacting the heavy and light phases below a lowermost one of the trays by:

distributing the light-phase feed stream adjacent the lower inlet across a lower distribution zone;

passing the heavy phase downwardly from the lowermost tray into the lower distribution zone for countercurrently contacting the light phase in the lower distribution zone;

passing the heavy phase downwardly from the lower distribution zone to an accumulation zone for coalescing the heavy phase essentially free of entrained light phase;

discharging the heavy phase as an effluent from a lower outlet of the extraction vessel in communication with the accumulation zone.

[c13] The method of claim 10, further comprising constraining the upward flow of the light phase through respective trays with flow restrictions in the risers.

[c14] The method of claim 13 wherein the flow restrictions comprise a restrictive cross-sectional area of the at least one top riser of the tray.

[c15] The method of claim 13 wherein the flow restrictions comprise a perforated restrictor plate between the top and bottom riser sections.

[c16] The method of claim 10, further comprising alternating configurations of the risers on the successive trays wherein the risers comprise single-pass peripheral risers.

[c17] The method of claim 10, further comprising alternating configurations of the risers on the successive trays wherein the risers comprise midsection-peripheral two-pass risers.

[c18] The method of claim 10, further comprising alternating configurations of the risers on the successive trays wherein the risers comprise midsection-peripheral three-pass risers.

[c19] The method of claim 10, wherein a ratio of the volumet-

ric flow rate of the light phase to the volumetric flow rate of the heavy phase is in a range from 1.5:1 to 15:1.

[c20] The method of claim 10, wherein the heavy liquid phase comprises solvent and the light liquid phase comprises raffinate.

[c21] The method of claim 10, wherein the heavy liquid phase comprises raffinate and the light liquid phase comprises solvent.

[c22] The method of claim 21, wherein:

the heavy-phase feed stream comprises lubricating oil feedstock containing asphaltenes;

the light-phase feed stream comprises solvent selected from aliphatic or cycloaliphatic hydrocarbons having from 3 to 5 carbon atoms; and

a ratio of the volumetric flow rate of the light phase to the volumetric flow rate of the heavy phase is in a range from 6:1 to 10:1.

[c23] The method of claim 1, further comprising:

securing removable blanking strips to the tray decks to block a first portion of the tray perforations and leave a second portion of the perforations unobstructed for said heavy phase passage;

removing at least one of the blanking strips to pass

the heavy phase through unobstructed perforations of the first portion.

[c24] The method of claim 1, further comprising:

securing adjustable blanking strips to the tray decks to selectively block and unblock at least a portion of the tray perforations;

adjusting the blanking strips to increase or reduce the rate of passage of the heavy phase through the respective portions of the tray perforations.

[c25] A liquid-liquid extraction unit for contacting a heavy liquid phase with a light liquid phase, comprising:

means for introducing a feed stream of the heavy phase for downward flow at a volumetric flow rate entering an upper inlet of a liquid-liquid extraction vessel comprising a plurality of successive, vertically-arrayed trays including at least one perforated deck per tray and at least one riser per tray, wherein the risers include respective top and bottom sections, wherein the bottom riser sections have larger transverse cross-sectional areas than respective top riser sections;

means for introducing a feed stream of the light phase into a lower inlet of the extraction vessel, for upward flow as a continuous phase at a volumetric flow rate greater than the heavy phase flow rate;

means for passing the heavy phase through perforations in the decks of successive trays to disperse droplets of the heavy phase into respective cross-flow zones below the decks;
means for collecting the heavy phase on respective upper surfaces of the successive trays;
means for passing the light phase through respective cross-flow zones into adjacent tray disengagement zones and through the respective risers to discharge into succeeding cross-flow zones.

[c26] A liquid-liquid extraction vessel comprising:
an upper inlet to the extraction vessel to introduce a feed stream of a heavy phase at a volumetric flow rate;
a plurality of successive, vertically-arrayed trays including at least one perforated deck per tray and at least one riser per tray, wherein the risers include respective top and bottom sections, wherein the bottom riser sections have larger transverse cross-sectional areas than respective top riser sections, and wherein a tray is imperforate in an area of the riser bounded between attachments of the respective top and bottom riser sections to the tray;
a lower inlet to the extraction vessel to introduce a feed stream of a light phase at a greater volumetric

flow rate than the heavy phase;
perforations in the tray decks to pass the heavy phase downward to disperse droplets of the heavy phase into a continuum of the light phase;
cross-flow zones below the respective tray decks to pass the heavy-phase droplets downwardly through the respective cross-flow zones;
collection zones below the respective cross-flow zones to coalesce the heavy-phase droplets on respective upper surfaces of successive decks;
disengagement zones under the bottom sections of the risers to receive the light-phase from the cross-flow zones and disengage entrained heavy phase droplets.

[c27] The vessel of claim 26, further comprising:
an upper distributor in communication with the upper inlet to distribute the heavy phase feed stream in the extraction vessel;
an upper distribution zone adjacent the upper distributor to contact the heavy and light phases in counter-current flow above an uppermost one of the trays;
an ultimate disengaging zone above the upper distribution zone to separate droplets of heavy phase from the light phase;

an upper outlet in communication with the disengaging zone to discharge light phase effluent from the extraction vessel.

[c28] The vessel of claim 26, further comprising:

a lower distributor in communication with the lower inlet to distribute the light phase in the extraction vessel;

a lower distribution zone adjacent the lower distributor to contact the heavy and light phases in countercurrent flow below a lowermost one of the trays;

an accumulation zone disposed below the lower distribution zone to coalesce the heavy-phase droplets;

a lower outlet in communication with the accumulation zone to discharge heavy-phase effluent from the extraction vessel.

[c29] The vessel of claim 26, further comprising flow restrictions in the risers to constrain the upward flow of light phase through respective trays.

[c30] The vessel of claim 29 wherein the restrictions comprise a restrictive cross-sectional area of the top risers.

[c31] The vessel of claim 29 wherein the restrictions comprise a perforated horizontal restrictor plate disposed in each riser.

[c32] The vessel of claim 29, further comprising directional passages in the risers to direct the flow of the light phase from the riser top sections laterally into respective cross-flow zones.

[c33] The vessel of claim 32 wherein the directional passages comprise a horizontal slot formed between a transverse cap attached above an open-ended riser stack and a top edge of the open riser.

[c34] The vessel of claim 33 wherein the directional passages comprise a plurality of side-facing openings in a vertical wall of a closed-ended riser stack.

[c35] The vessel of claim 26, wherein the risers comprise single-pass peripheral risers alternatingly disposed between opposite sides on the successive trays.

[c36] The vessel of claim 26, wherein the risers comprise mid-section-peripheral two-pass risers alternatingly disposed on the successive trays.

[c37] The vessel of claim 26, wherein the risers comprise mid-section-peripheral three-pass risers alternatingly disposed on the successive trays.

[c38] The vessel of claim 26, further comprising blanking strips removably secured to the perforated deck surfaces

to selectively block portions of the perforations.

[c39] The vessel of claim 26, further comprising blanking strips adjustably secured to the perforated deck surfaces to selectively block and unblock portions of the perforations.

[c40] The vessel of claim 26, further comprising personnel access hatches in the perforated tray decks wherein access panels of adjacent trays overlap in plan.

[c41] A method for converting a rotating disc contactor to a sieve tray liquid-liquid extraction unit comprising:

providing an existing rotating disc contactor;

selectively removing existing extraction vessel internal components from the rotating disc contactor selected from the group consisting of trays, packing, rotating discs, agitating internals, upper and lower feed distributors;

installing at least one tray including at least one perforated deck and at least one riser, wherein risers include respective top and bottom sections, wherein bottom riser sections have larger transverse cross-sectional areas than respective top riser sections, and wherein a tray is imperforate in an area of the riser bounded between attachments of the respective top and bottom riser sections to the tray.